Advanced Performance Coating System

Background:

Paint and depaint processes currently account for over 70% of the hazardous waste generated by the US Air Force. The application of primers and topcoats associated with painting and repainting of USAF aircraft in 1995 accounted for the release of an estimated 450,000 pounds of Volatile Organic Compounds (VOC). The Air Logistic Commands (ALC), MAJCOM Field Units, and Systems Program Directors (SPD) have incorporated a number of processes and materials to minimize VOC emissions and reduce the usage of hazardous compounds from its aircraft coating systems. These compounds are included in the Air Force Material Command (AFMC) 24, a list of the 24 hazardous materials. In addition to the AFMC 24, the Environmental Protection Agency (EPA) identified 17 hazardous materials and decreed a 33% reduction by the year 1999 and a 50% reduction by the year 2005 of these materials.

The Coating Technology Screening Committee (CTSC) created an Air Force Coating System Strategy which includes a Mid-Term Strategy. The goal of the Mid-Term Strategy is to reduce pollution in the paint process by developing higher performing coatings. Coatings with improved weatherability and cleanability are being developed to extend the coating system life and eliminate the need for repaint and touch-up between scheduled Programmed Depot Maintenance (PDM) cycles. Laboratory and limited flight testing of a urethane-fluoropolymer based topcoat from Deft, called Advanced Performance Coating (APC) has shown promise to meet these objectives. Deft teamed with AFRL, Boeing and the C-17 System Program Office (SPO) to develop APC. Based on these results, the USAF is interested in expanded use of APC. The Coating Technology Integration Office (CTIO) has been assigned the task of performing the engineering assessments to successfully integrate this topcoat.

Project Sponsor/Customer: C-17 SPD, AMC
Phase 1: APC Integration - Period of Performance: Mar 99 – Apr 01
Phase 2: APC Characterization - Period of Performance: Jun 00 – Sep 01

Phase 1: APC Integration

Objectives:

The goal of this project is to successfully integrate the APC topcoat. The technical objectives are:

- Determining the range of environmental conditions and processing parameters over which acceptable system performance can be achieved.
- Verification of the compatibility of APC with other aerospace finishing materials in order to identify any potential reliability and maintainability (R&M) problems.

Two topcoat colors were evaluated. Camouflage gray APC was compared with MIL-PRF-85285C, utilizing Deft 03-GY-321 as the control. Both camouflage topcoats meet Federal Color Standard 595B 36173. The gloss white APC is planned to be evaluated against two topcoats: 1) Awlgrip from US Paint Corporation, and 2) MIL-PRF-85285C utilizing Deft 03-W-127A as the control. All gloss topcoats meet Federal Color Standard 595B 17925.

Status:

Laboratory testing has been completed. Finishes were exposed in the artificial weathering chambers to QUV-B for 2000 hours, QUV-A for 3000 hours and Xenon Arc between 2000-3000 hours.

The following tests were conducted utilizing five climatic conditions during application and cure:

- <u>Dry time</u>. Determines the effect of temperature and humidity on the drying time of the APC compared to polyurethane topcoat
- <u>Potlife</u>. Low Shear via Ford Viscometer and Rotational via Brookfield Viscometer. Determines the potlife of the topcoats as a function of time under each climatic condition of temperature and humidity.
- <u>Water Resistance Test</u>. Determines the amount of cure time needed to ensure water resistance as a function of temperature and humidity present during application and cure.
- <u>Coating Cure utilizing MEK double rubs</u>. Compares the MEK resistance of APC with MIL-C-85285 when cured 3 days at selected climates of application and cure plus 11 additional days at ambient room temperature
- <u>Accelerated Weathering – UVB-Condensation cycle.</u>

- Evaluates the weathering resistance of the cured coating system as a function of temperature and humidity present during application and cure and to assess the effect of this accelerated weathering on flexibility of the coating system.
- Accelerated Weathering – UVA-Condensation Cycle. Evaluates the weathering resistance of the cured coating system as a function of temperature and humidity present during application and cure and to assess the effect of this accelerated weathering on flexibility of the coating system.
- Accelerated Weathering – Xenon Arc Weatherometer. Evaluates the weathering resistance of the cured coating system as a function of temperature and humidity present during application and cure.
- Fluid Resistance. Evaluates the fluid resistance of the cured coating system as a function of temperature and humidity present during application and cure.
- Strippability. Evaluates the strippability of APC compared with MIL-PRF-85285C.

Test Performance:

- APC possessed improved weathering qualities and higher cleaning efficiencies than the control, MIL-PRF-85285C.
- APC demonstrated equal to superior water resistance and fluid resistance to the control.
- Dry time of APC was equal to or faster than the control.
- The viscosity of APC increased more as a function of time and temperature than the control.
- Water immersion did not reduce the pencil hardness values of the APC as much as the control.
- The film performance of APC when applied near the end of the pot life was the same as the control.
- APC and the control exhibited MEK resistance even after only 24 hours cure time.
- APC and control surfaces were tacky after 24 hours with environmental conditions of 60 degrees F/20% RH or 60 degrees F/80% RH and testing was delayed until 48 hours of cure.
- FT-IR and UV-VIS weathering data suggests the surface chemistries of the APC topcoat vary as a function of the primer (epoxy, polyurethane, polysulfide). The differences in the IR and UV spectra showed distinctly different concentrations of functional groups in the APC topcoat as a function of the different primers.

- With the exception of polysulfide primer, APC demonstrated superior fade resistance when subjected to all three accelerated weathering protocols.
- Washing the systems caused a greater color change in the control than in APC.
- APC has exhibited superior fade resistance on C-17s in actual exterior weathering. These C-17s use epoxy primer from Dexter, which exhibited excellent weathering properties in the laboratory.
- All systems exhibited fluid resistance to hydraulic leaks and jet fuel at 48 hours cure. APC was equal to or better than the control for resistance to Skydrol
- APC was less flexible than the control and showed significantly less flexibility after exposure to accelerated weathering.
- APC possessed greater cleaning efficiency than the control after exposure to Xenon Arc weathering with all primer systems except polysulfide primer.
- APC exhibited fluid resistance equal to or superior to the control. Resistance to Skydrol was poor to fair, but greater than the control.
- APC and the control demonstrated equal compatibility with the non-chrome tiecoats and no deficit was noted to prevent recoating existing AF paint systems.
- The only apparent deficits in APC were reduced flexibility and greater viscosity increase in time and temperature

Test Plan: Approved May 99
Final Report: Planned Completion Mar 01

Phase 2: APC Characterization

Objectives:
The CTIO is assessing reliability and maintainability (R&M) issues and possible problems concerning the Advanced Performance Coating (APC). These issues and problem areas encompass surface treatment, cleaning, and the paint application processes. This assessment will ensure the APC is compatible with real-world operations, conditions, procedures, and practices. Field-testing will be conducted to validate if the APC will be an improvement over the currently used MIL-PRF-85285 topcoat. CTIO will assess the performance of the APC by taking color, gloss, film thickness, and hardness readings on test aircraft at six-month intervals during the test period. CTIO will provide the expertise for a smooth transition from MIL-PRF-85285 to APC, by providing guidance to the field units, MAJCOMs, and ALCs that adopt APC as

the topcoat in the refinishing process.

The objective of this project is to identify any performance problems/difficulties with the use of APC relative to MIL-PRF-85285 that would mitigate the AF from adopting APC as the primary topcoat for OEM, depot PDM cycle operations and field repaint activities. Other objectives include providing engineering solutions to problems identified, and developing of an AMS specification for coatings systems using APC.

Key project activities include:

- Monitor test aircraft painted with APC
- Test APC compatibility with leading edge coating protection materials
- Test APC gloss white under varying environmental conditions
- Test APC over two JG-PP non-chrome primer candidates
- Evaluate APC strippability
- Create APC system specification

Status:
There is a low probability the gloss-white APC will be available from the manufacturer during the project time period. Currently, no gloss white testing is planned.

The testing of the JG-PP non-chrome primers coated APC using EA chemical strippers was completed. Using EA strippers, APC was generally more difficult to strip than the control MIL-PRF-85285. No difference was seen with the JG-PP non-chrome primers. Methylene chloride based strippers worked equally well with both topcoats. Using polysulfide primer, under the test conditions, all topcoats were stripped, but the primer was essentially untouched. A draft system specification for APC was developed. After 500 hours of xenon arc exposure, Delta E's averaged 0.4 for all 6 test systems (APC and MIL-PRF-85285, over the 2 JG-PP non-chrome primers and MIL-PRF-23377G). Analysis of variance indicated no significant differences between any of the systems. After 500 hours of QUV B, Delta E's ranged from 4.8 (MIL-PRF-85285 over the Dexter JG-PP primer) to 0.46 (APC over MIL-PRF-23377G). Analysis of variance of the data indicates that APC is performing significantly better that MIL-PRF-85285, and (regardless of topcoat) both JG-PP non-chrome primers are inferior to MIL-PRF-23377G. The analysis shows weathering of topcoats over the Dexter primer is inferior to those over the Spraylat primer. The Spraylat primer tested is a dark green. This primer color was sufficiently dark that a visible difference (Delta E = 1) was seen in the initial color of the topcoats compared to the same topcoat over the other primers. Accelerated weathering is continuing. Drying times of primers and topcoats were determined at (Temp/RH) of 77/50, 60/20, 60/80, 90/20, and 90/80. CTIO attended the October G8/G9 meeting where the draft specification was provided to coatings vendors, other government agency representatives, and aerospace OEM’s for comment.

Project Plan: Approved Aug 00
Test Plan: Approved Aug 00
Final Report: Planned Completion Sep 01
As of Date: Feb 01